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1. Your reference JGP/8840 GB

2. Patent application number
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0308003.3
07 APR 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
Airbus UK Limited
New Filton House
Filton, Bristol
BS99 7AR
United Kingdom

Patents ADP number *(if you know it)*
08352890001

If the applicant is a corporate body, give the country/state of its incorporation
United Kingdom

4. Title of the invention Landing gear

5. Name of your agent *(if you have one)*
Abel & Imray

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*
20 Red Lion Street
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United Kingdom

Patents ADP number *(if you know it)*
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Signature Abel & Imray Date 7 April 2003

Abel & Imray

12. Name and daytime telephone number of person to contact in the United Kingdom: J G Pearson - (01225) 469914

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Landing gear

The present invention relates to landing gear. In particular, the invention relates to landing gear designed to reduce the noise generated by the interaction of the landing gear and the air flowing past it during flight, take-off and/or landing.

It is desirous to minimise the noise generated by aircraft, for example, to lessen disruption or inconvenience, resulting from aircraft noise, caused to the public on the ground near airports A significant amount of noise is generated by the interaction of the landing gear and the air flowing past it, which results in turbulent flows and consequently noise.

It is an aim of the present invention to provide a landing gear that generates less noise compared to a landing gear of the same size that has not been adapted, designed or manufactured in accordance with the present invention.

According to a first aspect of the present invention there is provided an aircraft landing gear so arranged that in its operative position it is configured to reduce, in use, the noise generated by the interaction of the landing gear and the air flowing past the landing gear. Thus the landing gear is advantageously arranged or configured so that the noise generated during landing of the aircraft by means of the landing gear interacting with air flowing past the landing gear is reduced compared with an arrangement of the landing gear not having the features according to the invention, but otherwise being identical. The landing gear or a part thereof may for example be designed to reduce, in use, the amount of turbulent air flow generated in the region of the landing gear. Alternatively, or additionally, the landing gear or a part thereof may be designed to streamline, in use, the flow of air past the landing gear. The landing gear may

for example include at least one noise-reducing element. The noise-reducing element may of course perform another function. The noise-reducing element may for example be in the form of one or more separate fairings. The noise-reducing element may be in the form of a conventional component of the aircraft landing gear that has been shaped or positioned in such a way as to reduce noise.

According to a second aspect of the present invention there is provided an aircraft landing gear including a pitch trimmer that during landing determines the pitch angle of a bogie, to which the wheels are attached, wherein the landing gear is so configured in its operative position that, in use, the noise generated by the interaction of the landing gear and the pitch trimmer is reduced. The pitch trimmer may for example be configured or arranged to generate less noise. For example, the pitch trimmer may generate less noise by having a streamlined cross-section (for example, a cross-section that generates less noise than a circular cross-section). The cross-section could for example be oval in shape, with for example the long axis aligned generally with the longitudinal axis of the aircraft. For example, the long axis of the oval may be generally coplanar with the longitudinal axis of the aircraft. For example, the long axis of the oval may be generally parallel when viewed from above with the longitudinal axis of the aircraft. The long axis of the oval need not therefore be parallel with longitudinal axis of the aircraft. (The term "generally aligned" should be interpreted similarly when used below.) Thus, the pitch trimmer may have a cross-sectional shape in the general form of an oval, arranged so that in use the long axis of the oval is aligned generally with the direction of the flow of air in the surrounding region. The cross-section could alternatively be generally teardrop shaped. This second aspect of the invention, whilst described with reference to a pitch trimmer,

may also have application with regard to other components of the aircraft, for example, one or more torque reacting members (such as brake rods for example). Thus, there is also provided a landing gear including one or more brake torque reacting members each having a cross-sectional shape in the general form of an oval, arranged so that in use the long axis of the oval is aligned generally with the direction of the flow of air in the surrounding region.

According to a third aspect of the present invention there is provided an aircraft landing gear including a load bearing support, the support including a first end which is attached, or is attachable, to a wheel assembly and a second end, which is opposite to the first end, and which is attached, or is attachable, to an aircraft, wherein the first and second ends are connected via a piston and barrel arrangement comprising a piston connected to the second end and a barrel connected to the first end.

The piston and barrel arrangement may be in the form of a shock absorber arrangement as is known in the art.

It is common practice to have a landing gear with the piston and barrel arrangement arranged such that the piston is connected to the first end and the barrel is connected to the second end. Such an arrangement has become common practice in the art, possibly for reasons associated with minimising the total weight of the arrangement. However, we have overcome this technical prejudice in the art and propose effectively to invert the piston/barrel arrangement of the landing gear. This inversion of the piston/barrel arrangement makes several features possible that may have benefits in terms of noise reduction as is explained in further detail below.

The barrel may be in the form of a conventional cylinder that accommodates a piston. The barrel is advantageously arranged and configured to have a streamlined shape. For example, the barrel may be faired. The barrel may

additionally or alternatively be oval in cross-sectional shape. The piston may also be oval in cross-sectional shape, but is advantageously circular in cross-section. Advantageously, the piston and barrel arrangement is so configured that, when connected to the aircraft with the landing gear in an operative position and the piston and barrel are extended to the normal operating maximum extension, the majority of the piston is accommodated inside the aircraft. Preferably, 75% of the exposed part of the piston is accommodated inside the aircraft, and more preferably, substantially all of the exposed part of the piston is accommodated inside the aircraft, for example inside the aircraft gear storage cavity.

The inversion of the piston and barrel arrangement may also facilitate the positioning of noise-generating parts or components of the landing gear out of the air-flow and into the interior of the aircraft. Examples of such components that could be so positioned inside the aircraft include the steering actuators and the torque links. It will be understood that positioning such components so that they are only partly within the interior space of the aircraft will provide some benefit in terms of noise reduction and it will therefore be understood that such components need not be wholly contained within the interior of the aircraft. It is however preferred for the majority of each such component to be within the aircraft. Preferably, 75% of the or each component is accommodated inside the aircraft, and more preferably, substantially all of the component is accommodated inside the aircraft.

According to a fourth aspect of the present invention there is provided an aircraft landing gear including a plurality of longitudinal load bearing supports, the supports being arranged in parallel and such that, in use when the landing gear is in an operative position, they are arranged

one behind the other in the direction of the air flow. The plurality of longitudinal load bearing supports are preferably so arranged that when the landing gear is in the operative position each load bearing support is so arranged that the long axis of the support is substantially perpendicular to the longitudinal axis of the aircraft. At least one of the load bearing supports may include a shock absorbing element. The or each shock absorbing element may include a piston and barrel arrangement. In the case where at least two of the load bearing supports include shock absorbing elements, one of the shock absorbing elements may advantageously be configured to have a different shock absorbing capacity from at least one of the other shock absorbing elements. Preferably, two of the load bearing supports are arranged to be able to vary the pitch of a bogie, on which the wheels are mounted. Such an arrangement makes it possible for the bogie not to be provided with a separate pitch trimmer. Two of the load bearing supports may be configured to withstand significantly different loads. One of the load bearing supports may for example have a greater cross-sectional area or may be made from a different material. One load bearing support being configured to withstand a different load from another of the load bearing supports may be of particular advantage in the case where the supports are arranged to perform a pitch trimming function.

The landing gear may advantageously be arranged such that one or more service pipes, cables, conduits, or the like, are provided between at least two of the longitudinal load bearing supports. By having such an arrangement, the service pipes, cables, conduits, or the like, may be shielded from the air flow. Noise that might otherwise be generated by the service pipes, cables, conduits, or the like, may therefore be reduced. Preferably two or more, and more preferably more than three, service pipes or conduits may be provided between

at least two of the longitudinal load bearing supports. The service pipes, cables, conduits or the like may include one or more of the group consisting of pipes for hydraulic fluid, cables for conducting power and/or electronic signals, or other pipes, cables or the like for providing services to parts of the landing gear.

The front load bearing support is preferably at least partly faired by a fairing element when the landing gear is in its operative position. The fairing element preferably extends around at least two of the load bearing supports. The fairing element preferably encompasses, but not necessarily encases, at least two of the load bearing supports. The fairing may be substantially oval in cross-section. The cross-section may, and preferably does, vary along its length.

According to a fifth aspect of the present invention there is provided an aircraft landing gear including a load bearing support, and one or more parts of the landing gear that are conventionally positioned in the airflow (for example positioned generally upstream of the load bearing support in the direction of the airflow), wherein said one or more parts are designed to generate less noise. For example, said one or more parts may be shielded from the airflow by a part of the landing gear. Whilst said one or more parts may be shielded from the airflow by a fairing, it is preferred that said one or more parts are shielded from the airflow by another part of the landing gear that serves a function other than fairing. Said one or more parts may at least partly be shielded from the airflow by a part of the load bearing support, or by a part of the structure (for example a bogie) on which the wheels of the landing gear are mounted. Said one or more parts may at least partly be shielded from the airflow by a part of the axle on which the wheels are mounted.

According to an especially preferred feature of the fifth aspect of the present invention said one or more parts are in

the form of a tow bar. For example, the landing gear may include a tow bar provided behind the main structure of the landing gear (downstream of the main structure of the landing gear in the direction of the flow of air). The landing gear may include a tow bar, movable between a storage position and an operative position, and the tow bar, in the storage position, is provided behind the main structure of the landing gear (downstream of the main structure of the landing gear in the direction of the flow of air). The tow bar may be positioned behind a bogie and/or by a part of the axle on which the wheels are mounted. The tow bar may in its operative position be positioned in front of the main structure of the landing gear (or at least in front of the part of the landing gear that, when the tow bar is in its storage position, shields the tow bar, for example the bogie and/or axle).

According to another especially preferred feature of the fifth aspect of the present invention said one or more parts are in the form of one or more brake torque reacting members for reacting the brake torque. Thus, there is provided an aircraft landing gear including a load bearing support, and one or more brake torque reacting members for reacting the brake torque that is generated in use by braking of the wheels, wherein the brake torque reacting members are designed to generate less noise. For example, the brake torque reacting members may be shielded from the airflow by a part of the landing gear. Whilst the torque reacting members may be shielded from the airflow by a fairing, it is preferred that the torque reacting members are shielded from the airflow by another part of the landing gear that serves a function other than fairing. The torque reacting members may at least partly be shielded from the airflow by a structure on which the wheels are mounted, for example a bogie and/or by a part of the axle on which the wheels are mounted. The torque reacting

members may for example be positioned generally downstream of the structure on which the wheels are mounted (in the direction of the airflow). For example, where the structure that shields the torque reacting members is a bogie, the shielding effect may be achieved by positioning the torque reacting members above the bogie, so that on approach when the bogie is positioned at an angle to the direction of travel (for example with fore of the bogie being positioned above the aft of the bogie), the members are at least partly shielded by the bogie. Alternatively, the one or more torque reacting members could be formed as part of the main structure of the landing gear, possibly by simply redesigning the landing gear so that the braking torque that is generated in use by braking of the wheels is reacted through part of the structure of the load bearing support and/or the structure on which the wheels are mounted, for example a bogie. The brake torque reacting members may generate less noise by having a streamlined cross-section (for example, a cross-section that generates less noise than a circular cross-section). The cross-section could for example be oval in shape, with for example the long axis aligned generally with the direction of the flow of air in the surrounding region (or with the longitudinal axis of the aircraft). The cross-section could be generally teardrop shaped. The brake torque reacting members may be in the form of brake torque rods. The landing gear may include a bogie on which one or more wheels are mounted, and at least one brake rod used to effect braking of the wheel(s) is housed within, or formed as part of, the body of the bogie.

According to another especially preferred feature of the fifth aspect of the present invention said one or more parts are in the form of a pitch trimmer that during landing determines the pitch angle of a bogie to which the wheels are attached. Thus, there is provided an aircraft landing gear including a load bearing support, one or more wheels mounted

on a bogie, which is pivotably mounted on the load bearing support, and a pitch trimmer, that during landing determines the pitch angle of the bogie, wherein the arrangement and configuration of the pitch trimmer is designed to generate less noise. For example, the pitch trimmer may be shielded from the airflow by a part of the landing gear. Whilst the pitch trimmer may be shielded from the airflow by a fairing, it is preferred that the pitch trimmer is shielded from the airflow by another part of the landing gear that serves a function other than fairing. The pitch trimmer may at least partly be shielded from the airflow by a part of the load bearing support. The pitch trimmer may for example be positioned downstream of, for example behind, the load bearing support (in the direction of the airflow). The pitch trimmer may be streamlined in shape as described with reference to the second aspect of the invention.

Above, reference is made to the brake torque reacting members and/or the pitch trimmer having a streamlined cross-sectional shape. This feature may of course be of independent benefit. Thus, the invention provides according to a sixth aspect of the present invention an aircraft landing gear including a load bearing support and at least one other component that is generally elongate in shape, has a longitudinal axis that is in use transverse to the flow of air when landing, has a streamlined shape and performs a technical function other than, or in addition to, streamlining the shape of the aircraft during flight. The component may not for example be a fairing. The component may for example be a pitch trimmer, brake rod, actuator, torque reacting member, strut or other mechanical device associated with the landing gear. The component may generate less noise by having a streamlined cross-section (for example, a cross-section that generates less noise than a circular cross-section). The cross-section could for example be oval in shape, with for

example the long axis aligned generally with the longitudinal axis of the aircraft. The cross-section could be generally teardrop shaped. This sixth aspect of the invention may be contrasted and compared with features of the second aspect of the invention relating to the streamlining of a pitch trimmer and features of the fifth aspect of the invention relating to the streamlining of a torque reacting member. In particular, features of these aspects of the invention may where appropriate be applicable this sixth aspect of the invention and vice versa.

In the case where the landing gear includes a bogie on which the wheels are mounted, noise may be reduced during landing by ensuring that the bogie and associated wheels are positioned relative to the airflow to reduce the noise generated by the interaction of the bogie and wheels with the air flowing past. According to a seventh aspect of the present invention there is provided an aircraft landing gear including a load bearing support, and one or more wheels mounted on a bogie, which is pivotably mounted on the load bearing support, wherein the pitch angle at which the bogie is presented to the airflow is such that, in use, the noise generated by the interaction of the bogie and/or wheels with the air flowing past is reduced. The pitch angle at which the bogie is presented to the airflow is advantageously controlled to reduce, in use, the noise generated by the interaction of the bogie and/or wheels with the air flowing past. Conventionally, the angle of the length of the bogie (which is horizontal when the aircraft is on the ground) is at a pitch angle of greater than 30 degrees to the direction of air flow in the region of the bogie. According to this preferred aspect of the invention the position of the bogie is advantageously configured and/or controlled so that the angle is less than 30 degrees during the approach on landing. More preferably, the pitch angle is configured/controlled to be

less than 25 degrees, and even more preferably less than 20 degrees, to the direction of air flow in the region of the bogie, during the approach on landing. The angle is advantageously configured/controlled to be less than 15 degrees, and even more advantageously less than 10 degrees. Ideally, the bogie is configured and/or controlled so that the pitch angle is substantially parallel with the direction of air flow in the region of the bogie, during the approach on landing. The pitch angle need not be kept below a threshold angle for all of the approach on landing. For example, immediately before touch down the pitch angle of the bogie may be increased so that it is greater than 10 degrees, and possible greater than 20 degrees or greater than 30 degrees, to the ground. There may be a control unit that is arranged to control the pitch angle during approach on landing. The control unit may be provided separately from the rest of the landing gear.

In the aspects of the invention described herein where reference is made to a load bearing support it may be the case that the or each load bearing support includes a shock absorbing element, for example, including a piston and barrel arrangement.

As mentioned above one or more fairings may be provided to assist in reducing unwanted noise on landing. One or more fairings may, for example, be provided which is/are configured and arranged as to cause air flow diversion that reduces unwanted noise. The one or more fairings could be arranged not only to divert air away from parts of the landing gear that generate unwanted noise, but also to alter the aerodynamics of the landing gear so as to indirectly divert air away from such parts. For example, the one or more fairing elements could be so configured and arranged as to cause some of the air flowing in the region of the landing gear to form an air curtain. Preferably, the air curtain so

formed assists in diverting air away from parts of the landing gear that generate unwanted noise. It will of course be appreciated that the air curtain may not be stable in form and will have a form that varies and is possibly rather complicated in shape. The air curtain would almost certainly not for example be planar in shape. The air curtain may be formed in such a way that a quiet region is formed between the landing gear and the air curtain. The quiet region insofar as this aspect of the invention is concerned may be defined as a region in which the average air velocity is significantly less than the average air velocity in a region on the other side of and adjacent to the air curtain. The quiet region may alternatively be defined as a region in which the average air velocity is significantly less than the average air velocity that would have existed had the air curtain not been present. The quiet region may alternatively be defined as a region in which the noise generated is significantly less than the noise that would have been generated had the air curtain not been present.

The air curtain may be formed by means of the fairing including an air-intake that is fed via an air-duct to an air exhaust, the air exhaust being so shaped that, in use during approach on landing, it causes the air flowing out of the air exhaust to form at least a part of the air-curtain. Alternatively or additionally, the landing gear may include a fairing that is so configured and arranged as to cause some of the air flowing in the region of the landing gear to form an air curtain and a quiet region between the landing gear and the air curtain

The landing gear may include at least one movable operative element that is positioned substantially away from the airflow that passes over the landing gear when the landing gear is in its operative position. The landing gear may include at least one movable operative element that is at

least partly housed within the landing gear bay when the landing gear is in its operative position. The landing gear may include at least one movable operative element that is substantially entirely housed within the landing gear bay when the landing gear is in its operative position. The landing gear may include at least one movable operative element that is substantially oval in cross-section, the element being positioned, when the landing gear is in its operative position, with the long axis of the oval being generally aligned with the general direction of the airflow. Said at least one movable operative element may comprise at least one steering actuator used to effect steering of the wheel(s) of the landing gear. Said at least one movable operative element may comprise at least one braking actuator used to effect braking of the wheel(s) of the landing gear. Said at least one movable operative element may comprise at least one torque link. Said at least one movable operative element may comprise at least one oleo of the hydraulic shock absorber of the landing gear. Preferably, said at least one movable operative element includes all movable operative elements of the same type. For example, all steering actuators on the landing gear may be formed as part of said at least one movable operative element so that, for example, all the steering actuators are positioned substantially away from the airflow that passes over the landing gear when the landing gear is in its operative position. The same may be true for example of the braking actuators, torque links, oleos, and any other movable operative element that forms a part of the landing gear.

The wheel of the landing gear is advantageously so arranged that no part of the braking assembly provided to brake the wheel protrudes from the side of the wheel. According to a eighth aspect of the invention, there is provided an aircraft landing gear including a wheel having a

brake assembly for braking the wheel, the brake assembly being arranged on one side of the wheel, said one side of the wheel being so arranged and configured that, during use of the landing gear on an aircraft when airborne and the landing gear is in a position ready for landing of the aircraft, the surface of the wheel presented to the airflow is substantially smooth in shape and preferably substantially planar.

The landing gear may be one of the main landing gear of the aircraft. The landing gear may be the or one of the nose landing gear of the aircraft. The landing gear may be in the form of a central landing gear, for example generally in line with central longitudinal axis of the aircraft. The landing gear may be in the form of a wing gear. Some aspects of the above-mentioned invention are especially relevant or well suited to particular types of landing gear. For example, the inversion of the landing gear according to the third aspect of the invention and the positioning of the tow bar behind the landing gear are each particularly well suited to a nose landing gear. Conventionally the nose landing gear of an aircraft is not provided with a bogie on which the wheel(s) are mounted. Thus, in relation to the aspects of the present invention that are concerned with or relate in some way to a bogie, it is preferred that the landing gear is in the form of a landing gear large enough to warrant the provision of a bogie (for example a main landing gear).

Aircraft having landing gear that are fixed in position are generally not designed with noise reduction in mind. The invention is of greater application to larger aircraft, particularly passenger-carrying aircraft, where noise reduction on landing of the aircraft is of greater relevance. The landing gear is preferably of a size suitable for use on an aircraft designed to carry more than 50 passengers, and more preferably more than 100 passengers. Such aircraft generally have retractable landing gear assemblies.

Above the term "load bearing support" is used with reference to different aspects of the invention. The or each load bearing support may be in the form of a column which transfers at least the majority of the load between the wheels to which the landing gear is in use attached and the body of the aircraft when the aircraft weight is supported by the wheels. The or each load bearing support may be in the form of a column that is so positioned as to connect one or more wheels to the aircraft.

Reference is made herein to the landing gear being in an operative position. It is intended that the operative position of the landing gear covers the case where the landing gear is in a position ready for landing. It may of course be the case that the landing gear is not movable from its operative position. The present invention is of particular application, however, where the landing gear is movable from an operative position (when the landing gear is deployed) to a stored position. For example, in its stored position the landing gear may be wholly contained within the interior of the aircraft, for example within a landing gear bay.

The aircraft landing gear referred to above with reference to the present invention may of course be manufactured separately from the aircraft and the wheels that in use would be connected to the landing gear. Thus the invention further provides a landing gear for use in the aircraft landing gear described herein with reference to any of the aspects of the invention. The landing gear may for example not be provided with the aircraft or any wheels.

The invention also provides an aircraft including a landing gear according to any aspects of the invention as described herein.

According to the present invention there is also provided means for converting a conventional landing gear into a landing gear according to any aspects of the invention as

described herein, wherein the means includes at least one noise reducing element. The means may for example be one or more fairing elements or one or more components that are streamlined in shape.

The present invention also provides a method of reducing noise caused by landing gear on an aircraft including a step of manufacturing a landing gear according to any aspects of the invention as described herein. The method may for example include a step of modifying an existing design in order to reduce noise caused by the landing gear.

There is yet further provided a method of flying an aircraft during the approach on landing the aircraft including a step of using one or more components of the aircraft landing gear to reduce the noise generated by the interaction of the landing gear and the air flowing past the landing gear, wherein the landing gear is in accordance with any of the aspects of the invention mentioned herein. For example, the landing gear may include a bogie where the pitch angle may be varied and the method includes controlling the pitch angle during at least part of the approach on landing to reduce noise. In the case where a pitch trimmer of the bogie attached to the landing gear is mounted behind the leg of the gear, the method may include a step of causing the front wheels to touch down on landing before the rear wheels touch down.

Embodiments of the present invention will now be described by way of example with reference to the accompanying schematic drawings of which:

Figure 1a	is a diagrammatic side view illustration of an inverted nose gear according to a first embodiment of the invention;
Figure 1b	is a diagrammatic cross-section section of the nose gear shown in Fig. 1a;

Figure 2a is a diagrammatic side view illustration of a prior art main landing gear;

Figure 2b is a diagrammatic cross-section of the main landing gear shown in Fig. 2a;

Figure 2c is a diagrammatic cross-section of a main landing gear according to a second embodiment of the invention;

Figure 3 is a perspective view of a nose gear according to a third embodiment of the invention;

Figure 4a is a diagrammatic cross-section of the wheels and axle on the bogie of a prior art main landing gear;

Figure 4b is a diagrammatic cross-section of the wheels and axle on the bogie of a main landing gear according to a fourth embodiment of the invention;

Figure 4c is a diagrammatic cross-section of the wheels and axle on the bogie of a main landing gear according to a fifth embodiment of the invention;

Figure 4d is a diagrammatic cross-section of the wheels and axle on the bogie of a main landing gear according to a sixth embodiment of the invention; and

Figures 5a-d are side views of a main landing gear according to a seventh embodiment of the invention.

The embodiments of the invention as described herein all relate to an aircraft landing gear movable between a stored position and a deployed position, the landing gear being suitable for use on an aircraft designed to carry more 100 passengers and being so arranged that in its deployed position

it is configured to reduce the noise generated by the interaction of the landing gear and the air flowing past the landing gear. The same reference numbers are therefore used in relation to features common to all of the embodiments.

Figure 1a is a schematic diagram illustrating the principles of operation and design of a nose landing gear 1 according to a first embodiment of the invention. The gear 1 is shown in its deployed position and includes a central leg 2 comprising an oleo strut 3 and an oleo cylinder 4, which receives the oleo strut 3. The oleo strut and cylinder form a pneumatic shock absorber in a manner known in the art. The entire oleo strut 3 is housed within the landing gear bay 5, within the fuselage 6. The embodiment differs from prior art constructions in that the oleo strut and cylinder have been inverted, in that the aircraft body is coupled to the wheels via the strut 3 and then the cylinder 4. A cross-section taken along the line X-X is shown in Figure 1b, which shows the oval cross-sectional shape of the oleo cylinder 4. The long axis of the oval is aligned with the direction of travel of the aircraft, which is indicated by the arrow A in Fig. 1a. The oleo cylinder 4 is therefore more streamlined in shape than the conventional circular cross-sectional shape. The oleo strut 3 has a circular cross-section and is snugly received within an interior surface also having a circular cross-section of the cylinder 4. Providing the strut 3 on top of the cylinder 4 and therefore within the landing gear bay 5 allows other components that would otherwise contribute to unwanted noise production also to be placed within the bay 5. For example, both the torque links 7 and steering actuators 8 are positioned wholly within the landing gear bay 5.

Fig. 2a shows a main landing gear 121 according to a prior art construction. The gear includes a leg 102 comprising an oleo cylinder 104 that accommodates an oleo strut 103 positioned beneath. The strut 103 is coupled to the wheels

108 via a bogie 109. Figure 2b is a cross-section taken along the line Y-Y and shows the oleo cylinder 104 surrounded by various service pipes/conduits/cables 110. Figure 2c is a cross-section of a main landing gear 21 according to a second embodiment of the invention, the cross-section being at an equivalent location to the line Y-Y to illustrate the differences between the prior art construction shown in Figures 2a and 2b and the second embodiment. There are two legs 2a, 2b, the legs being parallel to each other, spaced apart and aligned in the direction of travel, which is indicated by the arrow A. All service pipes/conduits/cables 10 and other such services are provided between the two legs 2. The legs 2 and the services 10 are surrounded by a fairing 11, that is oval in shape, the long axis of the oval being aligned with the direction of travel of the aircraft. The area presented to the airflow as viewed in the direction of travel of the leg 2 is therefore less compared to the area presented by the leg 102 of the prior art construction. Also, noise generated by the services 110 previously positioned around the leg 102 is reduced by moving the services 10 out of the air flow. The two legs 2a, 2b each include a shock absorber in the form of an oleo strut and cylinder assembly. The shock absorber of the front leg 2a has different shock absorbing properties from the rear leg 2b. The ability of the legs 2 to have different shock absorbing properties reduces the structural need for torque links and trimming of the wheels. Thus, the noise that would otherwise be generated by the components required for reacting torques and for providing the trimming capability may be reduced.

Figure 3 shows a nose gear 1 according to a third embodiment of the invention. The landing gear 1 includes a tow bar 12 that is movable between a storage position and an operative position. The tow bar when in its storage position (as shown in Fig. 3) is positioned behind the main structure

of the deployed landing gear, in the direction of the flow of air (opposite to the direction of travel, which is indicated by the arrow A). When required for use, the tow bar 12 is moved to its operational position (not shown), which is in front of the main structure of the deployed landing gear 1. Thus, during the approach of the aircraft on landing, when the gear is deployed, the tow bar 12 is hidden behind and shielded by the axle 13 on which the wheels 8 are mounted. If the tow bar is to be used to move the aircraft in reverse then it can be used in its storage position, whereby the aircraft can be pulled in reverse. If on the other hand the tow bar 12 is to be used to move the aircraft forwards then the tow bar 12 is moved from its storage position to its operational position, whereby the aircraft can be pulled forwards.

Figure 4a shows a diagrammatic cross-section (viewed in the general direction of travel) of the wheels and axle on the bogie of a prior art main landing gear 121. Thus, on the bogie there are mounted two pairs of wheels 108 (only one pair of which are shown in Fig. 4a), each pair of wheels being mounted on an axle 113. Brake rods 114 are provided below the axle 113 and, because of the pitch angle of the bogie on approach, are positioned directly in the airflow and therefore generate unwanted noise during the approach on landing. The bogie includes a bogie beam 115 which runs the length of the bogie and is shown in cross-section in Fig. 4a.

Figure 4b is a diagrammatic cross-section of the wheels and axle on the bogie of a main landing gear according to a fourth embodiment of the invention, the section being similar to that shown in Figure 4a for ease of comparison with the corresponding prior art construction. In this embodiment, rather than providing brake rods having a circular cross-section (as provided in the prior art construction illustrated by Fig. 4a), the rods 14 have an oval cross-sectional shape. The long axis of the oval, when in its conventional angled

position during the approach on landing, is aligned with the direction of the airflow, in that the long axis is coplanar with the longitudinal axis of the aircraft (normal to the page). The brake rods 14 are therefore more streamlined and generate less noise.

Figure 4c is a cross-section of the wheels and axle of a main landing gear according to a fifth embodiment of the invention, the section being similar to that shown in Figures 4a and 4b for ease of comparison. In this embodiment, rather than providing brake rods below the axle and generally in the airflow on approach, the brake rods 14 are provided above the axle 13. The brake rods are therefore at least partly shielded from the airflow be means of the axle 13 so that the brake rods 14 generate less noise.

Figure 4d is a cross-section of the wheels and axle of a main landing gear according to a sixth embodiment of the invention, the section being similar to that shown in Figures 4a to 4c for ease of comparison. In this embodiment, rather than providing separate brake rods, the brake torque is reacted directly through the bogie beam 15. For this reason, the bogie beam 15 is slightly larger in cross-section than might otherwise be required (compare with Figs. 4a to 4c). The bogie beam does not however have a uniform structure and may for example be hollow in places or at least formed of less dense material in places so as not to increase weight unnecessarily. The absence of the brake rods reduces the production of unwanted noise.

Figures 5a to 5d are side views of a main landing gear 21 according to a seventh embodiment of the invention, in sequence illustrating the position of the bogie 9 of the landing gear during the landing sequence. The landing gear 21 includes a bogie 9 on which wheels 8 are mounted, a pitch trimmer 16 and a shortening mechanism 17. The pitch angle of the bogie 9 relative to the ground is partly dependent on the

position of the pitch trimmer 16 (or at least the position of the pitch trimmer 16 is partly dependent on the pitch angle). In contrast to constructions of the prior art, the pitch trimmer 16 is positioned behind the leg 2 of landing gear 21 in the direction of the flow of air (opposite to the direction of travel, which is indicated by the arrow A). Thus, the pitch trimmer 16 is shielded from the airflow. The repositioning of the pitch trimmer 16 has the effect that, on landing, the front wheel 8a on the bogie 9 touches down before the rear wheel 8b (see Fig. 5a, for example). The leg 2 includes a shock absorbing assembly including an oleo strut 23 and an oleo cylinder 24 (see Fig. 5b for example). Fig. 5a shows the landing gear 2 immediately after touch down of the front wheel 8a, where the landing loads are sustained by the front wheel 8a (the shortening mechanism having been locked in position). The pitch trimmer 16 is in a compressed state. As the load increases, the shock absorbing assembly 23, 24 starts to compress (see Fig. 5b). The rear wheel 8b then touches down as shown in Fig. 5c. The pitch trimmer 16 is now in an extended position. Thereafter, as shown in Fig. 5d, the shock absorber 23, 24 compresses further until a steady state is reached and the pitch trimmer 16 acts as a dampener (i.e. the pitch trimmer is in a ground damping mode).

According to an eighth embodiment, not separately illustrated, there is provided an aircraft landing gear including a leg, and a bogie on which four wheels are mounted. The bogie is pivotably mounted on the leg in a conventional manner. During landing, the pitch angle at which the bogie is presented to the airflow is however able to be controlled up to just before touchdown. During the approach when landing the pitch angle at which the bogie is presented to the airflow is controlled to be in line with the air flow, thereby reducing noise.

According to a ninth embodiment, not separately illustrated, there is provided an aircraft landing gear including a fairing that has a central air intake vent, that is connected via an air duct and manifold system to an air outlet means. The air outlet means includes several outlets, the outlets being arranged so that together, during the approach on landing, they act so as to divert at least partly, air away from noise generating regions of the landing gear by means of there being formed an air-curtain.

According to a tenth embodiment, not separately illustrated, there is provided an aircraft landing gear including a wheel and a braking assembly provided to brake the wheel. The braking assembly for each wheel includes several pistons and discs and other moving parts. Conventionally, such parts are cooled by means of being in the air flow and as such generate noise. In this embodiment the braking assembly is cooled by other means. The braking assembly is provided on one side of the wheel and, on that side, the surface of the wheel presented to the airflow is substantially smooth and flat in shape. Thus, the braking assembly is contained within the wheel, and no part of the mechanics of the braking assembly protrudes from the side of the wheel. Noise which would otherwise be generated by the wheel, and by protruding parts of the brake assembly, is thereby reduced. The cooling of the brakes is achieved by means of a flow of air that is channelled via air intakes and ducts to the braking assembly and then out of an air outlet. Channelling air for cooling of the brakes in this way creates less noise and yet allows the brakes to be kept from overheating in a simple and reliable manner.

Other embodiments of the invention are envisaged that benefit from the general principles of the present invention described herein. For example, if the pitch trimmer, or other parts of the landing gear are in the airflow, such parts may

be designed to have a more streamlined cross-section, for example an oval cross-section.

It will be appreciated that various modifications may be made to the above-described embodiments of the invention without departing from the spirit of the invention. For example, in relation to the seventh embodiment the pitch trimmer positioned behind the landing gear leg may be configured such that on landing the rear wheel touches down before the front wheel (as is conventionally the case).

Claims

1. An aircraft landing gear so arranged that in its operative position it is configured to reduce, in use, the noise generated by the interaction of the landing gear and the air flowing past the landing gear.

2. An aircraft landing gear according to claim 1, wherein the landing gear or a part thereof is designed to reduce, in use, the amount of turbulent air flow generated in the region of the landing gear.

3. An aircraft landing gear according to claim 1 or claim 2, wherein the landing gear or a part thereof is designed to streamline, in use, the flow of air past the landing gear.

4. An aircraft landing gear according to any preceding claim, wherein the landing gear includes at least one noise-reducing element.

5. An aircraft landing gear according to any preceding claim, wherein the landing gear includes a pitch trimmer that during landing determines the pitch angle of a bogie, to which the wheels are attached, and wherein the pitch trimmer has a cross-sectional shape in the general form of an oval, arranged so that in use the long axis of the oval is aligned generally with the direction of the flow of air in the surrounding region

6. An aircraft landing gear according to any preceding claim, wherein the landing gear includes one or more brake torque reacting members each having a cross-sectional shape in the general form of an oval, arranged so that in use the long

axis of the oval is aligned generally with the direction of the flow of air in the surrounding region.

7. An aircraft landing gear according to any preceding claim, wherein the landing gear includes a load bearing support, the support including a first end which is attached, or is attachable, to a wheel assembly and a second end, which is opposite to the first end, and which is attached, or is attachable, to an aircraft, wherein the first and second ends are connected via a piston and barrel arrangement comprising a piston connected to the second end and a barrel connected to the first end.

8. An aircraft landing gear according to claim 7, wherein the barrel has an oval cross-sectional shape.

9. An aircraft landing gear according to any preceding claim, wherein the landing gear includes a plurality of longitudinal load bearing supports, the supports being arranged in parallel and such that, in use when the landing gear is in an operative position, they are arranged one behind the other in the direction of the air flow.

10. An aircraft landing gear according to claim 9, wherein the landing gear is arranged such that one or more service pipes, cables, conduits, or the like, are provided between at least two of the longitudinal load bearing supports.

11. An aircraft landing gear according to claim 9 or claim 10, wherein the landing gear includes a fairing element that encompasses at least two of the load bearing supports.

12. An aircraft landing gear according to any preceding claim, wherein one or more parts of the landing gear are

shielded from the airflow by a load bearing support that forms a part of the landing gear, or by a part of the structure on which the wheels of the landing are mounted.

13. An aircraft landing gear according to claim 12, wherein said one or more parts are in the form of one or more brake torque reacting members for reacting the brake torque.

14. An aircraft landing gear according to claim 13, wherein the brake torque reacting members are shielded from the airflow by a part of the structure on which the wheels are mounted.

15. An aircraft landing gear according to claim 13, wherein the one or more torque reacting members are formed as a part of the structure on which the wheels are mounted so that the braking torque that is generated in use by braking of the wheels is reacted through said structure.

16. An aircraft landing gear according to claim 12, wherein said one or more parts are in the form of a pitch trimmer that during landing determines the pitch angle of a bogie, to which the wheels are attached, and wherein the pitch trimmer is positioned downstream of the load bearing support so that the pitch trimmer is shielded from the airflow.

17. An aircraft landing gear according to any preceding claim, wherein the aircraft landing gear includes a load bearing support, and one or more wheels mounted on a bogie, which is pivotably mounted on the load bearing support, wherein the pitch angle at which the bogie is presented to the airflow is such that, in use, the noise generated by the interaction of the bogie and/or wheels with the air flowing past is reduced.

18. An aircraft landing gear according to claim 17, wherein the pitch angle at which the bogie is presented to the airflow is controlled to be substantially parallel with the direction of air flow in the region of the bogie, during the approach on landing.

19. An aircraft landing gear according to any of claims 7 to 18, wherein the or each load bearing support includes a shock absorbing element.

20. An aircraft landing gear according to any preceding claim, including a fairing that is so configured and arranged as to cause some of the air flowing in the region of the landing gear to form an air curtain that creates a quiet region between the landing gear and the air curtain.

21. An aircraft landing gear according to any preceding claim, wherein the landing gear includes a wheel and a braking assembly provided to brake the wheel, and the landing gear is so arranged that no part of the braking assembly protrudes from the side of the wheel.

22. An aircraft landing gear according to any preceding claim, wherein the landing gear includes a wheel and a braking assembly provided on one side of the wheel to brake the wheel, and wherein the landing gear is so arranged that the surface of said one side of the wheel presented to the airflow is substantially smooth in shape.

23. An aircraft landing gear substantially as herein described with reference to any of the figures of the accompanying drawings.

24. An aircraft including a landing gear according to any preceding claim.

25. Means for converting a conventional landing gear into a landing gear according to any of claims 1 to 23, wherein the means includes at least one noise reducing element.

26. A method of reducing noise caused by landing gear on an aircraft including a step of manufacturing a landing gear according to any of claims 1 to 23.

27. A method according to claim 26 further including a step of modifying an existing design in order to reduce noise caused by the landing gear.

Abstract

Landing gear

An aircraft landing gear (1, 21) is arranged such that in its deployed position it is configured to reduce, during the approach on landing, the noise generated by the interaction of the landing gear (1, 21) and the air flowing past the landing gear. Various means are described to reduce the amount of turbulent air flow generated in the region of the landing gear (1, 21), including providing oval pitch trimmers and brake rods (14), inverting the nose gear shock-absorbing leg (3, 4), providing faired twin in-line oleos (2a, 2b,) shielding the brake rods (14), pitch trimmer (16) and tow bar (12) by providing them behind the gear leg (2), dispensing with brake rods altogether by reacting the torque though the bogie/axle beam (15), trimming the pitch angle of the bogie (9), providing fairings that produce shielding air curtains, and providing smooth sided wheels with all the brake assembly encased therein.

Fig. 2c to accompany the abstract on publication.

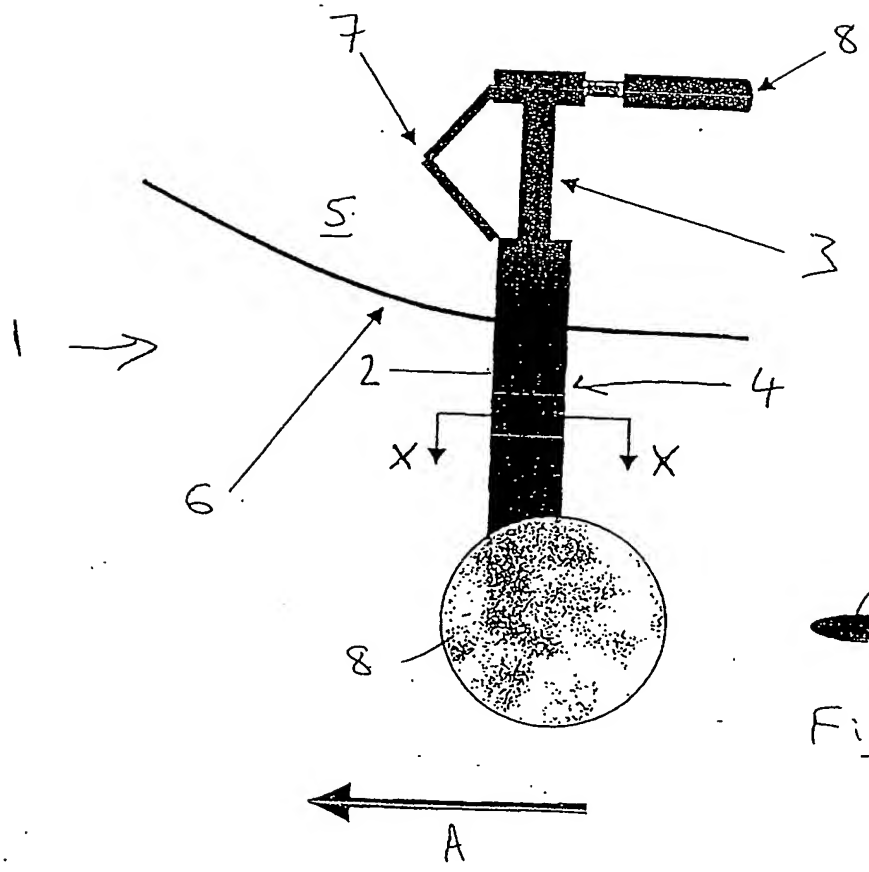


Fig 1a

Fig 1b

Fig 2a

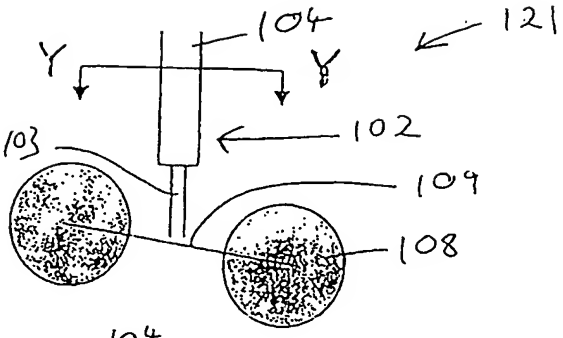


Fig 2b

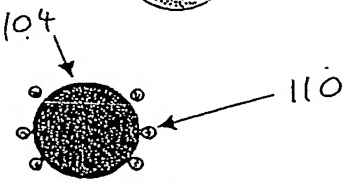
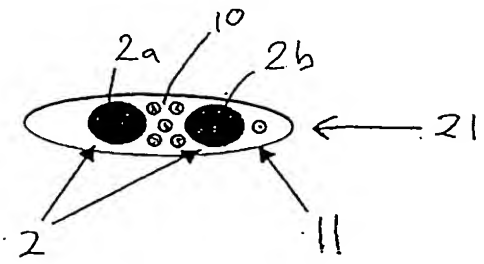
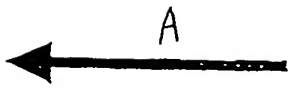


Fig 2c





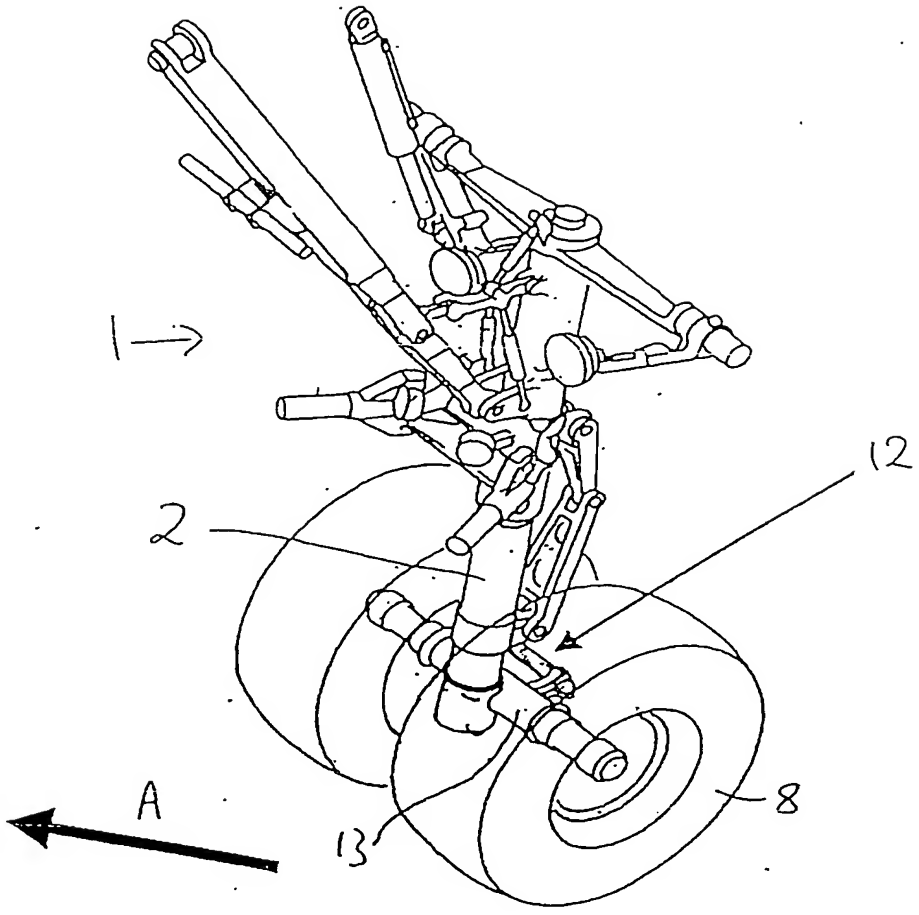


Fig 3

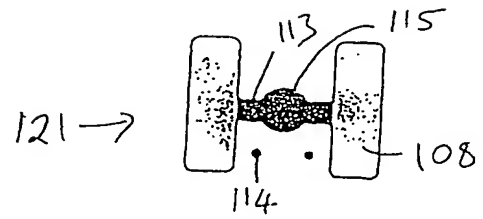


Fig 4a

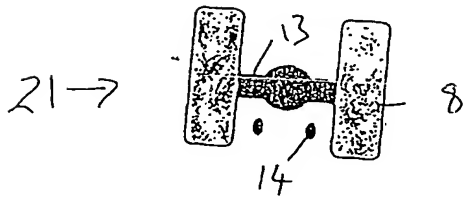


Fig 4b

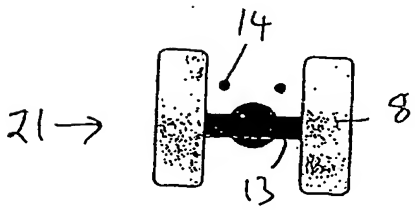


Fig 4c

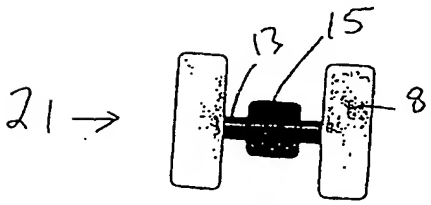


Fig 4d

Fig 5d

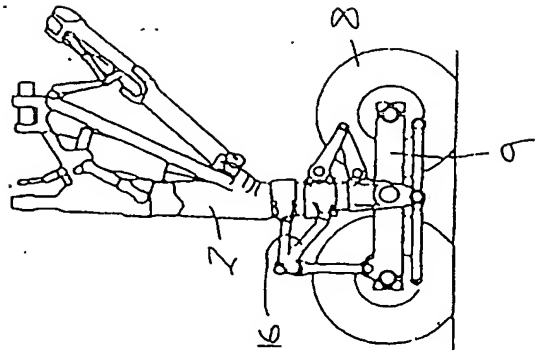


Fig 5c

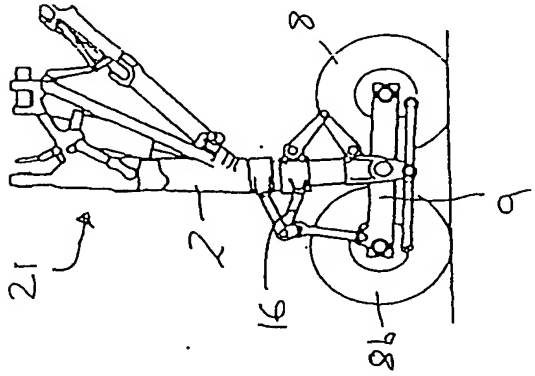


Fig 5b

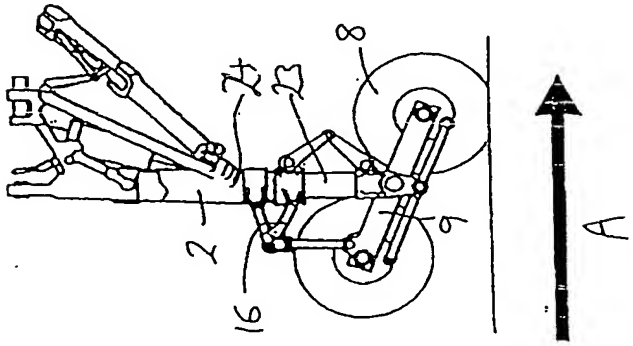


Fig 5a